Research of Lattice Boltzmann Method

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Abstract

The research objective is to implement Cumulant LBM for collision operator and validate it in terms of the solution accuracy, stability, and cost for high-Reynolds number flow. In addition, the source code of implemented Cumulant LBM is tuned aimed for fast computation.

Reasons and benefits of using JAXA Supercomputer System

The computational cost of unsteady flow simulation by LBM is very high.

We use JSS2 to reduce the computational time by paralleization.

Achievements of the Year

Cumulant LBM was implemented to current our code and validated through the comparison with SRT and Cascaded LBM in terms of solution accuracy, stability, and cost. In addition, due to the code tuning by writting down matrix calclation and SIMD, multiple relaxation model such as Cascaded LBM and Cumulant LBM can compute at 1.7 times the cost of SRT model.

before

```
for (int n = 0; n < Q; ++n) {
    ftmp[I][n] = 0;
    for (int m = 0; m < Q; ++m) {
        ftmp[I][n] += rho[I] * (Minv[m][n] * (CM[m] * (1 - omg[m]) + CMeq[m] * omg[m]));
    }
}
```

after

```
T ftmp_[Q];
for (int n = 0; n < Q; ++n) {
    ftmp_[n] = 0;
}
for (int m = 0; m < Q; ++m) {
    for (int n = 0; n < Q; ++n) {
        ftmp_[n] += rho[I] * (Minv[m][n] * (CM[m] * (1 - omg[m]) + CMeq[m] * omg[m]));
    }
}
for (int n = 0; n < Q; ++n) {
    ftmp[I][n] = ftmp_[n];
}
```

Fig. 1: Example of SIMD for collision operator

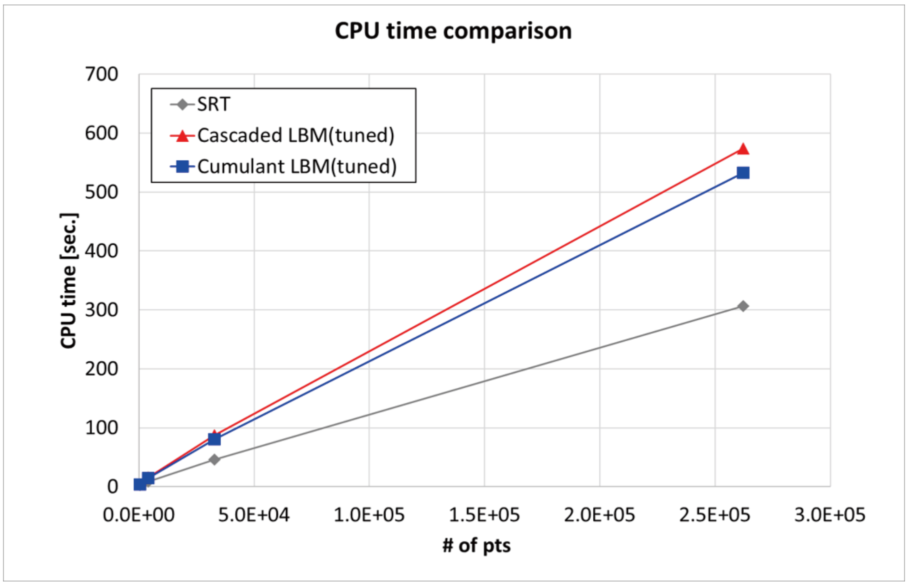

Fig. 2: Comparison of CPU time after code tuning

Publications

- Non peer-reviewed papers

1) Takashi Ishida, Daichi Asaoka, Masaharu Kameda, Unsteady flow simulation around an airfoil with low-speed and high angle-of-attack conditions by Lattice Boltzmann Method, 33th CFD Symposium

Usage of JSS2

Computational Information

Process Parallelization Methods	N/A
Thread Parallelization Methods	OpenMP
Number of Processes	1
Elapsed Time per Case	1000 Second(s)

Resources Used

Fraction of Usage in Total Resources*1(%): 1.28

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2(%)
SORA-MA	11,348,171.01	1.38
SORA-PP	15,318.40	0.10
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2(%)
/home	495.91	0.41
/data	49,018.88	0.84
/ltmp	5,859.38	0.50

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2(%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage：Percentage of usage relative to each resource used in one year.